

Validation of Satellite-Derived Cloud Top Heights in Tropical Cyclones using Observations from the NASA Global Hawk and CALIPSO

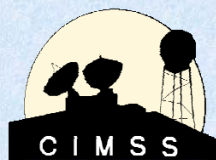
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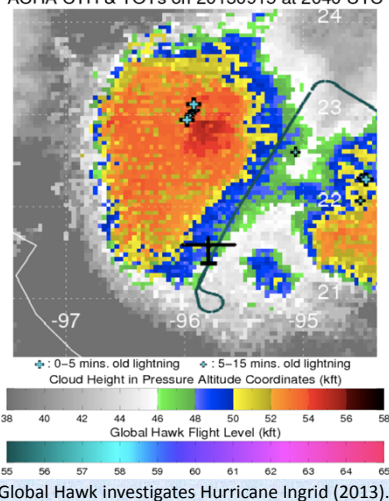


Motivation: Satellite-derived cloud top heights are used extensively in real-time for many meteorological applications. One of these is to assist the NASA Hurricane and Severe Storm Sentinel (HS3) field experiment with safe maneuvering of the Global Hawk aircraft when flying around Atlantic tropical cyclones (TCs).

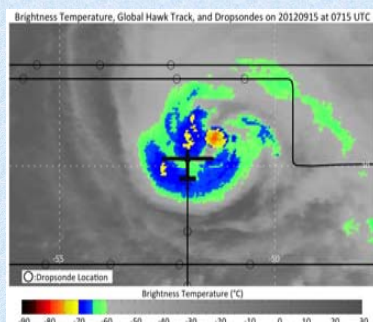
About the Cloud Height Algorithm (ACHA):

- In development by NESDIS in preparation for the GOES-R Advanced Baseline Imager (ABI).
- ACHA: ABI Cloud Height Algorithm (ACHA)
- Utilizes satellite IR data, as well as a radiative transfer model for other cloud properties.
- Employs the 11, 12 and 13.3 μm LW-IR band, so can operate night and day.
- Steps:
 - Identifies cloud-top brightness temperature, cloud emissivity, and optical depth.
 - Calculates the cloud-top temperature from the above variables.
 - Compares the cloud-top temperature to a collocated temperature profile provided by Numerical Weather Prediction data (GFS) to derive cloud-top height and pressure.

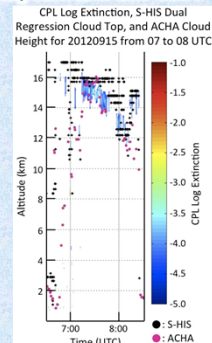
Lightning & Global Hawk on 20130915 at 2108 UTC
ACHA CTH & TOTs on 20130915 at 2040 UTC



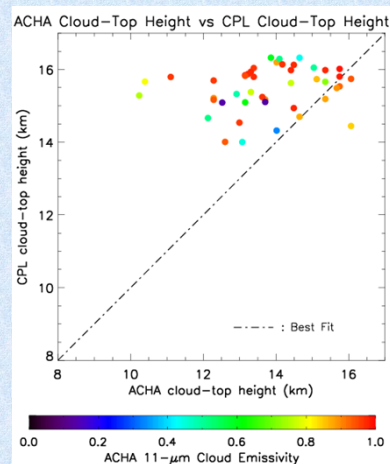
Comparing ACHA to the Cloud Physics Lidar (CPL) and Scanning High-resolution Interferometer Sounder (S-HIS) aboard the GH:



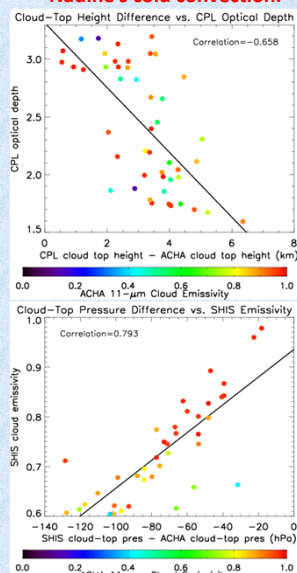
Above: At the location of the tail of airplane while flying over TS Nadine, ACHA estimates cloud top heights of ~50 kft.



ACHA cloud heights compare well to CPL and S-HIS heights over Nadine's cold convection.

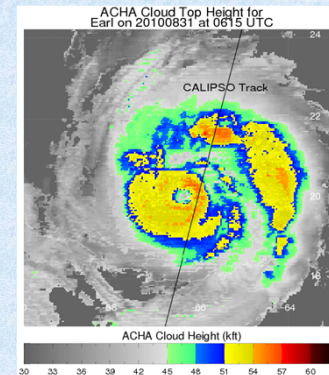


Comparison of collocated cloud-top height estimates by ACHA with CPL cloud-top heights above 14 km. Sample is from GH over-flights of TCs during the 2013 Atlantic field campaign. **ACHA cloud heights are generally lower than the CPL heights, which is likely a result of sensor resolution and cloud opacity/thickness properties.**

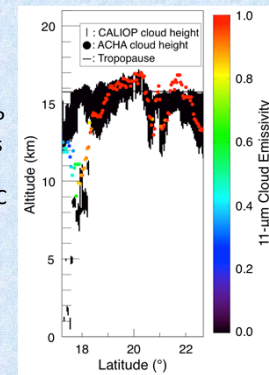


43.3% (62.9%) of the variability between the CPL (S-HIS) cloud-top heights (pressures) above 14 km (140 hPa) and corresponding ACHA cloud height (pressure) during HS3 2013 can be explained by the CPL optical depth (S-HIS emissivity).

Comparing ACHA to CALIPSO and the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP):

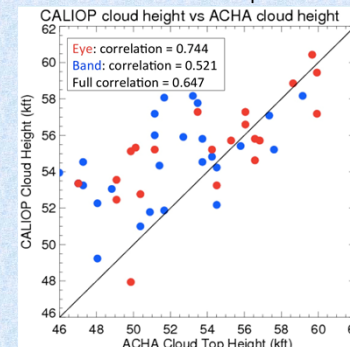


ACHA and CALIOP cloud top heights on August 31, 2010, at 0615 UTC over then Cat-4 Hurricane Earl.

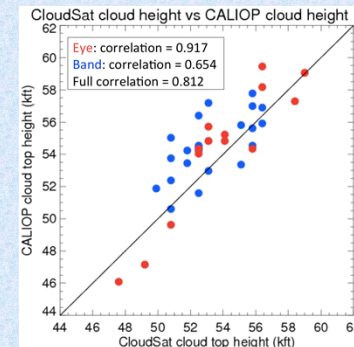


ACHA cloud heights match CALIOP well in the convective eyewall and outer band.

Comparisons from 42 West Pacific TCs



The ACHA cloud top heights show a general low bias compared to co-located CALIOP estimates, with higher correlation in colder convective eyewalls of the TCs.



Like ACHA, CloudSat is better correlated with the CALIOP cloud height in the eyewall of the TCs.

Summary:

- Comparison with CPL, S-HIS, and CALIOP indicate **the ACHA cloud-top heights match reasonably well in cold active cloud regions associated with tropical cyclones.**
- ACHA has a tendency to underestimate cloud top heights in less opaque cloud.**
- CPL optical depth can explain 43.3% of the variability between CPL cloud-top heights above 14 km and the corresponding ACHA cloud-top heights (**thinner clouds >> bigger differences**).
- S-HIS emissivity can explain 62.9% of the variability between S-HIS cloud-top pressures lower than 140 hPa and the corresponding ACHA cloud-top pressures.

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Support: NASA Hurricane Science Research Program (HSRP) Grant Number: NNX12AK63G